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(58) Field of search B8A

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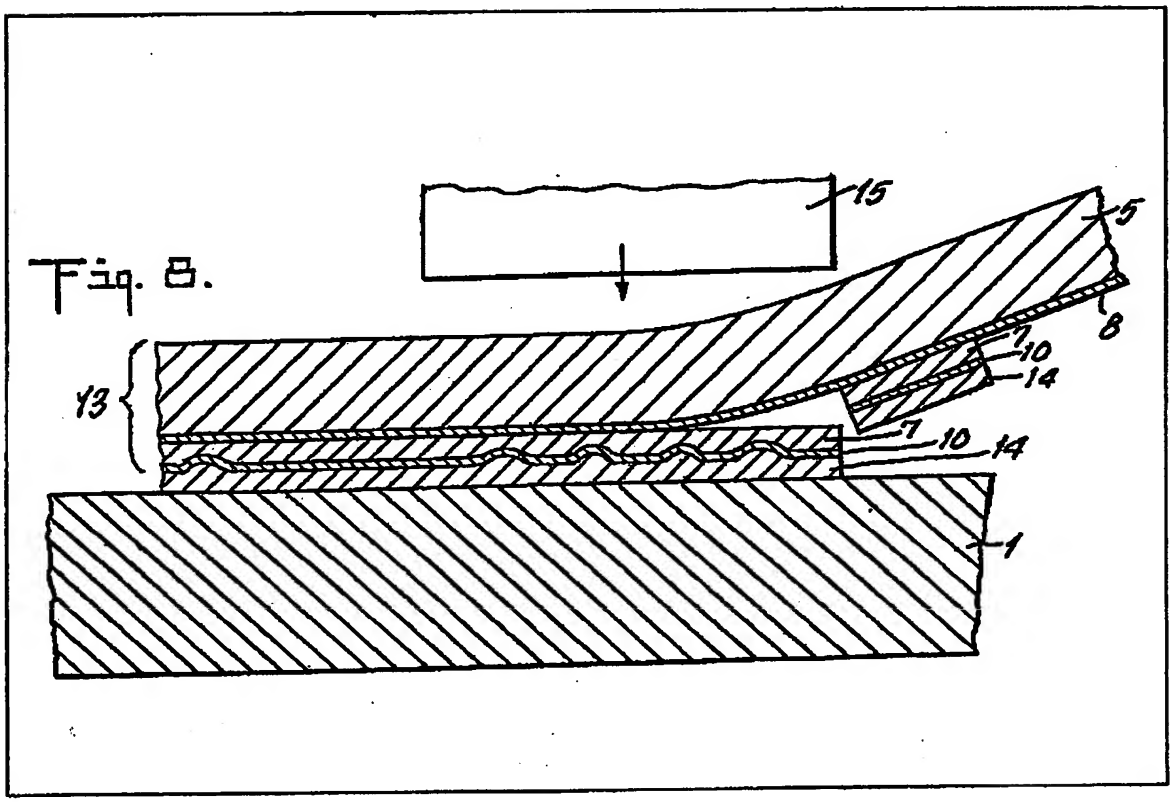
(54) **Processes and products for reproducing light diffracting patterns**

(57) A readable light diffracting record may comprise a substrate (1) and a transparent layer (7) attached to the substrate (1) and having its surface (10) nearest the substrate reflective and formed into a light diffracting pattern. The invention also provides a process for making a readable light diffracting record comprising preparing a laminate material (13) including a support layer (5) and a transparent layer (7) with the surface (10) of said transparent layer (7) most distant from the support layer (5) reflecting and formed into a light diffracting pattern, adhering said patterned reflective surface (10) of the laminate material (13) to a substrate (1), and removing the support layer (5). The light diffracting patterns or records of the invention may be incorporated as security features into security documents.



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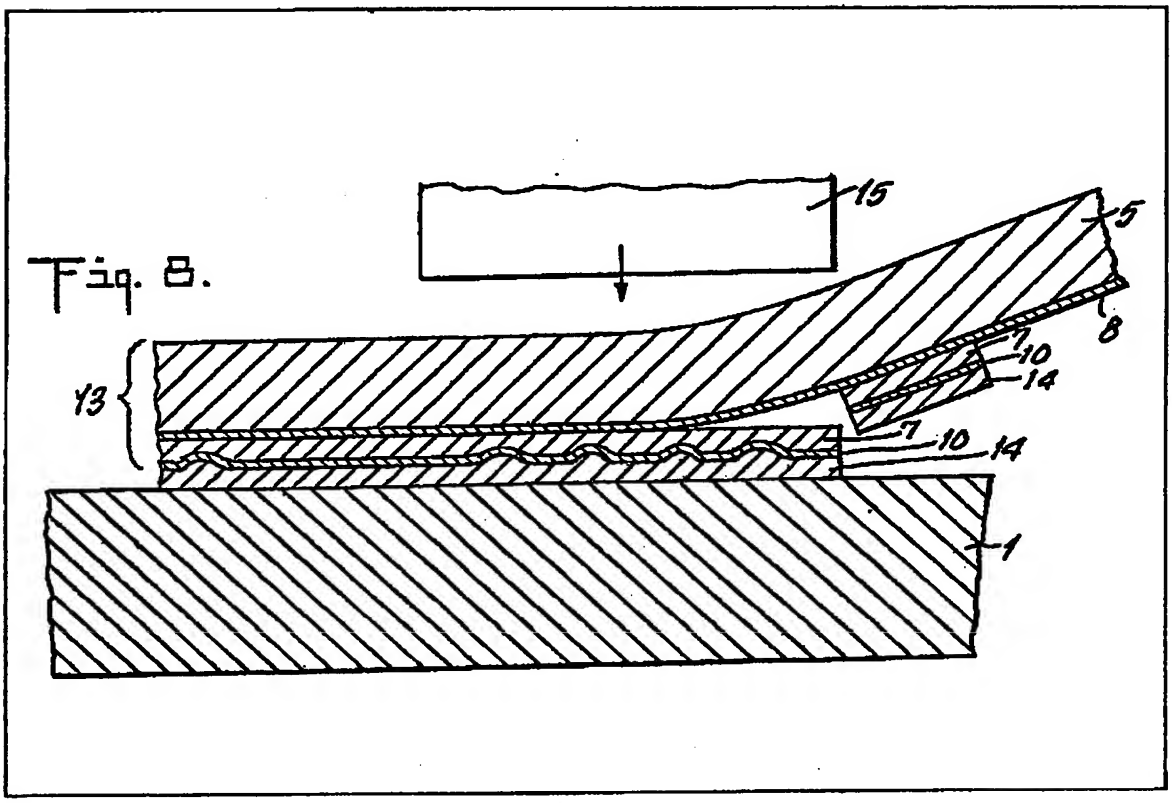

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Fig. 1.

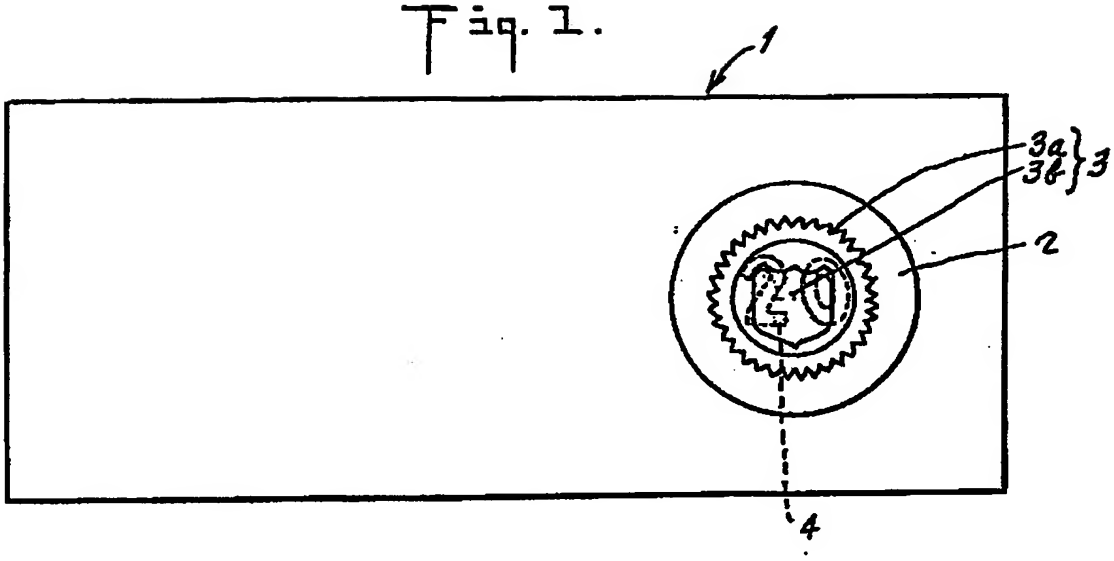


Fig. 4.

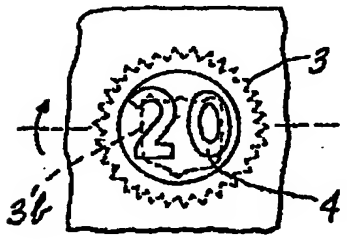


Fig. 2.

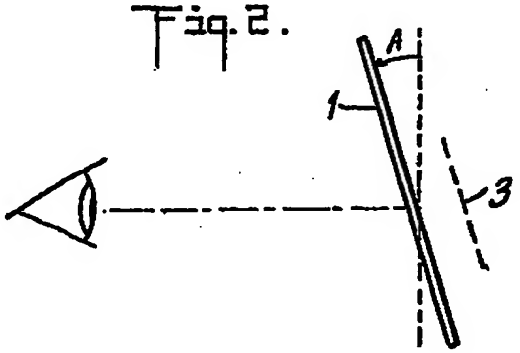


Fig. 5.

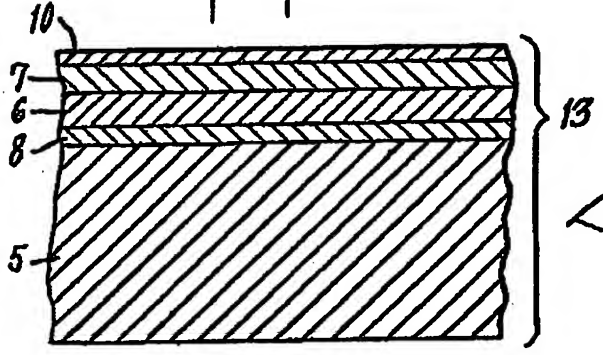
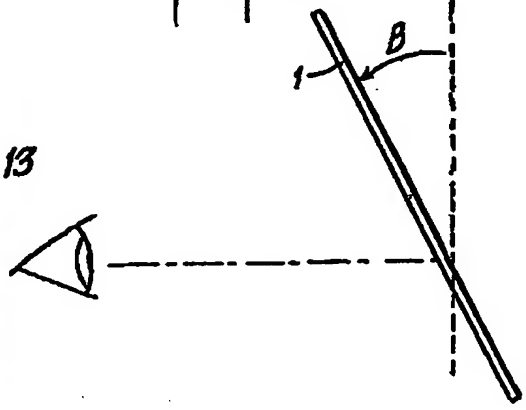


Fig. 3.



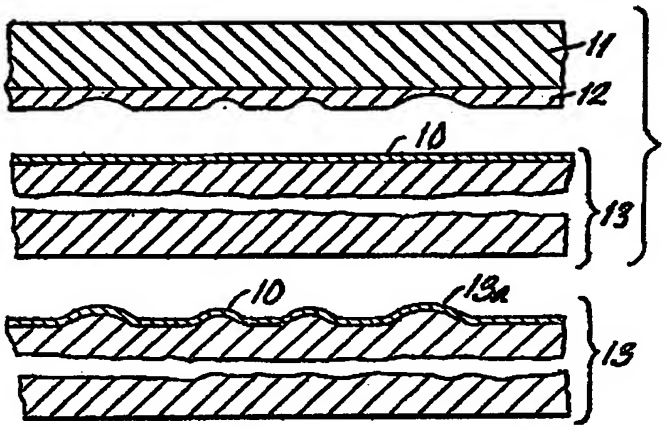
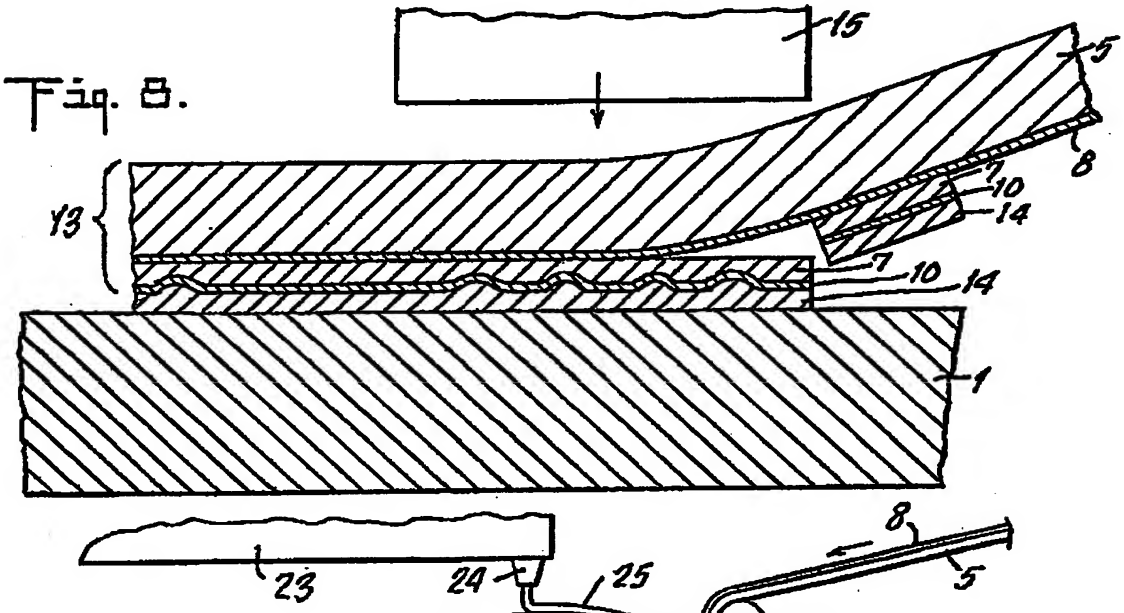


Fig. 6.

Fig. 7.

Fig. 8.



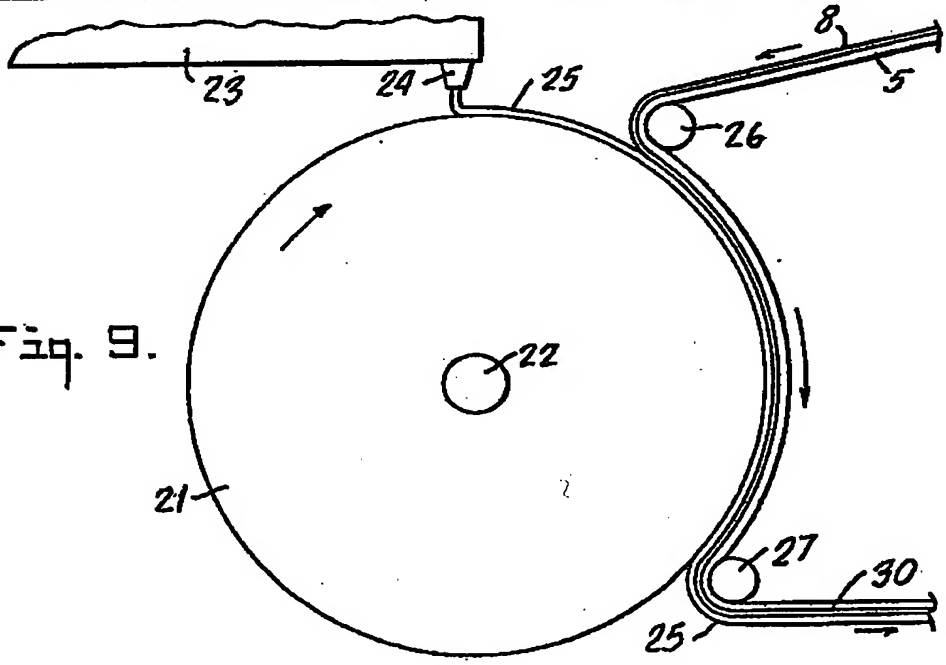


Fig. 9.

SPECIFICATION

Processes and products for reproducing light diffracting patterns

This invention relates generally to the field of light diffraction patterns, such as holograms or diffraction gratings, and is specifically concerned, although not restricted, with a method of machine application of holograms to paper and other substrates.

The construction of so-called "surface relief" holograms have been described by a number of authors, including Bartolini, et al., whose paper appeared in Applied Optics, Vol. 9, No. 10, in October 1970, pp. 2283-2290. This same paper describes methods of creating from photoresist holograms, nickel stamping dies which are subsequently used to emboss holograms into plastic sheet material. The methods of holography embossing, however, are not restricted as to technique, and one can use conventional embossing plates or rollers.

This invention aims to provide a technique for the application of certain thin, fragile embossed material to suitable substrate. The substrate can be very textured, and flexible as, for example, with some papers. The invention includes a technique which provides easy handling and machine processing of these materials by the use of a carrier web. This web may be manifested as rolls of material.

This invention thus permits the creation of documents containing gratings or holograms which are tamperproof by virtue of their fragility since they are destroyed by attempts to remove them from the document or other substrate.

The invention provides a readable light diffracting record comprising a substrate and a transparent layer attached to the substrate and having its surface nearest the substrate reflective and formed into a light diffracting pattern.

The invention further provides a process for making a readable light diffracting record comprising preparing a laminate material including a support layer and a transparent layer with the surface of said transparent layer most distant from the support layer reflective and formed into a light diffracting pattern, adhering said patterned reflective surface of the laminate material to a substrate, and removing the support layer.

The processes of making a hologram or diffraction grating according to the invention may begin with the making of a die having in its face a light interference pattern in relief. In one embodiment, laminated sheet material is prepared for receiving an embossment of a light diffracting pattern. This laminated sheet material includes a support layer, a release coat covering the support layer, one or more layers of thermoplastic material overlying the release coat and less sensitive to heat than the release coat, and a layer of foil, preferably metal, less than 1000 Angstrom units (Å) in thickness and bonded to the surface of the thermoplastic layer opposite to the release coat.

The die is then impressed into the foil and the adjacent thermoplastic layer to form an embossed light diffracting pattern therein. The embossment may be deeper than the thickness of the foil. The foil is then covered with an adhesive layer. The laminated sheet material is then inverted and pressed against the flexible substrate, e.g., paper, by a suitable pressure plate. This causes adhesion of the foil to the substrate and a separation of the support layer from the layer of thermoplastic material, due to the melting of the release coat. This adhesion and separation occurs only in those areas beneath the pressure plate. In other areas, the foil and thermoplastic layers are retained in contact with the support layer. When the support layer is lifted from the substrate, the foil and thermoplastic layers fracture along the edges of the pressure plate, so that what is left on the substrate is only the area, including the embossment, which was beneath the pressure plate. This process is similar to hot stamping. A major difference, of course, is the step of pre-embossing the laminated material with very thin diffraction and holographic patterns. Considerable care must be taken to preserve these patterns in this application step, and in selecting suitable release coat, thermoplastic, and reflective materials.

The thermoplastic material is transparent, although it may be coloured. The light diffracting pattern, now on the surfacte nearest the substrate, is visible through the transparent thermoplastic material as a reflection pattern. The thres-dimensional effect of a hologram or the irridescent effect of a diffraction grating may be readily observed, through the thermoplastic material.

The process is particularly useful in the preparation of documents of value, since the resulting document with a hologram or diffraction grating is impossible to make without the aid of expensive equipment. The embossed surface, being beneath the outer thermoplastic layer, is inaccessible. Also, the reflective layer and the thermoplastic layer, which constitute the foil remaining on the document or other substrate, are so thin that they are not self-supportive. This foil can be as thin as 2000 Å. Any attempt to remove it, so as to gain access to the embossed surface or to transfer it to a different substrate (document, etc.), results in its destruction.

The utility of the process and its product is not limited to documents of value, but may be used in the production of trade marks or labels, for example, or in the preparation of any document, or publication, or other record, where a particularly unusual and attractive effect is desired. In the prior art, the embossing and transferring processes are performed simultaneously, whereas with the techniequ disclosed herein these operations are perfomed separately. In certain prior art processes, the embossing is carried out through a carrier layer, thus limiting the fineness of the embossed pattern to the point that the embossing of holograms would not be possible, whereas with the technique disclosed herein there is no intervening layer. Such prior art processes result in an unprotected embossed surface which is accessible for tampering, whereas the technique disclosed herein automatically creates a sealed light diffracting surface.

The invention will now be further described and illustrated by way of specific embodiments and with

reference to the accompanying drawings, in which:-

Figure 1 is a plan view of a document of value carrying a hologram and a diffraction grating produced in accordance with the invention.

Figure 2 is an end view of the document of Figure 1, showing the direction and angle of tilt used to view the hologram image contained in the document.

Figure 3 is a diagrammatic view showing the direction and angle of tilt used to view the diffraction grating.

Figure 4 is a fragmentary view of part of the document of Figure 1, tilted as in Figure 3 to emphasize the diffraction grating more than the hologram.

Figure 5 is a cross-sectional view showing a laminated sheet material used in the process of preparing the documents of Figures 1 to 4.

Figure 6 illustrates the application of an embossing die carrying a light interference pattern to the upper face of the laminated material of Figure 5.

Figure 7 shows the material of Figure 5 after the die has embossed a pattern thereon.

Figure 8 illustrates the process of fastening the embossed laminated sheet material to a substrate by means of a stamping process.

Figure 9 illustrates, somewhat diagrammatically, an alternative process for forming an embossed laminated material.

Figure 1 illustrates a document of value generally indicated as 1, having applied thereto a circular disc 2 bearing a hologram containing an image of the shield 3 which appears to float in space behind the hologram surface. The disc 2 also carries a diffraction grating 4, shown in the form of the numeral 20. It is focused on the surface of the holgram and is shown in dotted lines. Both the hologram 3 and the diffraction grating 4 are visible. However, at a particular angle of observation, (the angle of tilt A in Figure 2) the image 3 is more sharply visible, so that the diffraction grating pattern 4 is shown in dotted lines. The image 3 is shown to appear behind the surface 1.

By tilting the document slightly about a horizontal axis, (increasing angle A in Figure 2 to B in Figure 3), the diffraction grating 4 may become the predominant visible feature and the components of the image 3 tend to become less prominent, as shown in Figure 2. Hence, the hologram 3 is shown in dotted lines in Figure 4. The images contained within the structure depicted in these figures may contain any of a variety of holographic images. Also, it should be apparent that the seal shown here need not be restricted to a circular configuration.

The terms "horizontal" and "vertical" are used in the above description with reference to the document as shown in Figure 1. "Horizontal" being the long dimension of the document and "vertical" being the short dimension of the document.

Figures 5 to 8 illustrate one embodiment of a process for preparing the embossed hologram and attaching it to the document.

There is first prepared a laminated structure 13 comprising a support layer 5, which may be polyester and which may have a thickness of one-half to one mil. The support layer is covered by a release coat 8, which may be a material which is sharply sensitive to increased heat, e.g., a suitable wax. Over the release coat there is provided a layer of thermoplastic material 6, which is less sensitive to heat, i.e., has a higher melting point than the release coat. A second thermoplastic layer 7 is placed on top of the layer 6 and a layer of thin reflctive foil 10, preferably aluminium, is placed over the second thermoplastic layer and bonded thereto.

Both of the thermoplastic layers may be transparent. The layer 6 is chosen for its wear resistant properties since it will be the outside layer on the finished product. A single layer thermoplastic layer may be used in place of the layers 6 and 7, if its wear resistant properties are suitable.

After the laminated material 13 of Figure 5 is prepared, it is placed under a die 11 having a die face 12 formed as a surface relief hologram. This is shown in Figure 6. Several methods of constructing a metal hologram embossing die are known in the art. The die 11 is pressed against the laminated material 13, thereby deforming the foil 10 and forming an embossment 13a in the laminated material, as shown in Figure 7.

The foil 10, including the embossment 13a is now covered with a hot melt adhesive layer 14. As shown in Figure 8, the laminated mterial 13 is inverted and placed upon the substrate to which it is to be attached, which may be the document shown in Figure 1. The document may bear conventional printing, preferably intaglio. That printing is preferably applied before the process of the invention is carried out, but may alternatively be done later. A pressure plate or stamping die (15 in Figure 8) is then applied to the laminated material 13 superimposed on the paper 1 and is held against the laminated material while applying heat and pressure sufficient to cause adhesion of the laminated material 13 to the paper 1. The hot melt adhesive is absorbed into the pores of the paper 1. The release coat 8 melts, allowing removal of the support layer 5. The outer layer is now the thermoplastic layer 6 or 7, both of which are transparent. There is produced on the face of document 1 a disc 2, having a hologram and a diffraction grating visible from its face as described in connection with Figures 1 to 4.

The process described above may be utilized for a single hologram, without an accompanying diffraction grating, or it may be utilized for a diffraction grating without a hologram. It is also possible to use it for a plurality of holograms or a plurality of diffraction gratings. A mixture of plural holgrams or plural diffraction gratings may be used. The particular image which is observed at any time will depend upon the angle at which the document is tilted by the viewer.

Instead of using a metal foil 10 which is bonded to the surface of the thermoplastic 6, one can deposit, by vacuum deposition, or other methods, a thin layer of aluminium or other reflective material, onto the surface of the thermoplastic 6. Alternatively, this deposition may be carried out after the embossing step shon in Figures 6 and 7, but before the application of the adhesive shown as 14 in Figure 8.

Another possibility of producing the laminated material 13 containing a surface relief hologram, involves casting, rather than conventional embossing.

The hologram laminated layers 6, 7 and 10, which are retained on the document 1, may be as thin as 2000 Angstrom units. This laminate should preferably be so delicate that the material will not hold together, if an attempt is made to transfer the holographic seal from the document 1.

Figure 9 illustrates an alternative process for forming a laminated structure 30 corresponding to the structure 13 of Figure 8 and impressing a hologram upon it. Figure 9 shows a cylinder 21 rotating on a shaft 22. The cylinder 21 carries a hologram in relief on its outer surface. The hologram is repeated at intervals about the periphery of the cylinder 21.

Transparent material from a suitable supply 23 is fed through a nozzle 24 and is deposited as a fluent sheet 25 on the surface of the rotating cylinder 21. A laminated web consisting of support layer 5 and release coat 8 is fed from a suitable source over a guide roller 26 so that it engages the outer surface of the sheet 25. The cylinder 21 may be heated at the point of contact of the sheet 25 with the laminated web. The sheet 25 is forced into contact with the relief holograms on the surface of cylinder 25. Part of the cylinder may be chilled, if necessary, before it reaches another guide roller 27 where the laminated material, now indicated at 30, is removed to a suitable take-up reel (not shown). In effect, the sheet 25 may be described as being cast between the die cylinder 21 and the laminated web including the support layer 5. The holograms are now impressed on the sheet of transparent material 25. The laminated material 30 leaving the guide roller 27 differs from the material of Figure 5 in that a single transparent layer 25 is used in place of the two transparent layers 6 and 7 of Figure 5.

A reflective surface, comparable to the foil 10 of Figure 5, may then be placed on the transparent material 25 by depositing an aluminium coat thereon, for example, by vapour deposition or sputtering. The laminated material of Figure 9 is then the equivalent of that shown in Figure 8.

The substrate may be paper or a suitable substitute for paper. For example, the polyethylene film-fibril sheets shown in the U.S. Patent Specification No. 247,318, may be used. Other suitable substrates may be employed, for example, rigid plastics such as are used for credit cards and the like.

The contours of the embossments are shown as rounded. The scale of the drawings is greatly enlarged. It is difficult to the point of impossibility to determine whether a particular peak or valley in an actual structure is sharp or rounded. The rounded showing is believed to be correct.

CLAIMS

1. A readable light diffracting record comprising a substrate and a transparent layer attached to the substrate and having its surface nearest the substrate reflective and formed into a light diffracting pattern.

2. A readable record as claimed in claim 1, wherein the transparent layer is attached to the substrate by a bond having a shear strength greater than the shear strength of the transparent layer.

3. A readable record as claimed in claim 2, in which said transparent layer has a thickness of from 1 to 10 microns.

4. A readable record as claimed in claim 2 or claim 3, in which said transparent layer includes a metallic layer on its reflective surface, said metallic layer being less than 1,000 Angstroms thick, and said light diffracting pattern includes indentations in said reflective surface and said metallic layer, at least part of said indentations being deeper than 1,000 Angstrom units.

5. A readable record as claimed in any one of claims 2 to 4, in which said light diffracting pattern comprises a hologram.

6. A readable record as claimed in any one of claims 2 to 5, in which said light diffracting pattern comprises a diffraction grating.

7. A readable record as claimed in any one of claims 2 to 6, in which said substrate is flexible and the record is a document of value, said transparent layer is non-cohesive and thereby not removable as a unit from the substrate.

8. A readable record as claimed in any one of claims 2 to 7, in which the transparent layer comprises a relatively soft stratum nearest the substrate and a stratum of abrasion resistant material covering said relatively soft stratum.

9. A readable record as claimed in claim 1 and substantially as hereinbefore described.

10. A readable light diffracting record substantially as hereinbefore described with reference to and as illustrated in Figures 1 to 4 of the accompanying drawings.

11. A process for making a readable light diffracting record comprising preparing a laminate material including a support layer and a transparent layer with the surface of said transparent layer most distant from the support layer reflective and formed into a light diffracting pattern, adhering said patterned reflective surface of the laminate material to a substrate, and removing the support layer..

12. A process for making a readable light diffraction pattern comprising prepering a sheet material including a support layer and a transparent layer having one surface adjacent the support layer and an opposing reflective surface formed into a light diffracting pattern, thereafter adhering the sheet material to a substrate with the formed reflective surface nearest the substrate, and separating the support layer from the transparent layer.

13. A process as claimed in claim 12, in which said transparent layer is non-self-supporting and the substrate is supportive.

14. A process as claimed in claim 12, in which the transparent layer is dimensionally unstable unless supported and the substrate is supportive.

15. A process as claimed in any one of claims 12 to 14, in which said preparing step includes providing a release coat between the support layer and the transparent layer.

16. A process as claimed in any one of claims 12 to 15, in which said adhering step includes providing a heat sensitive adhesive layer between the transparent layer and the substrate.

17. A process as claimed in any one of claims 12 to 16, in which said adhering and separating steps are accomplished by applying heat and pressure to the superimposed layers constituted by the sheet material and substrate to cause adhesion of the transparent layer to the substrate and separation of the support layer from the transparent layer.

18. A process as claimed in claim 17, in which the heat is applied to the side of the substrate opposite the side adjacent to the reflecting surface.

19. A process as claimed in any one of claims 12 to 18, in which said opposing reflective surface of the transparent layer is covered by a thin metallic layer.

20. A process as claimed in claim 19, in which said thin metallic layer has a thickness of less than 1,000 Angstrom units.

21. A process as claimed in any one of claims 12 to 20, in which said transparent layer is thermoplastic.

22. A process as claimed in any one of claims 12 to 21, in which said transparent layer has a thickness of less than 5,000 Angstrom units.

23. A process as claimed in any one of claims 12 to 22, in which in said preparing step the transparent layer is applied to said support layer as a liquid and subsequently solidified.

24. A process as claimed in any one of claims 12 to 23, in which the transparent layer remaining on the substrate after separation of the supper layer has a thickness of from 1 to 10 microns.

25. A process as claimed in any one of claims 12 to 24, in which in said preparing step said reflective surface is formed into a light diffracting pattern by pressing the transparent layer against a die having a light diffracting pattern in relief thereon.

26. A process as claimed in any one of claims 12 to 24, in which in said preparing step said reflective surface is formed into a light diffracting pattern by casting fluent transparent material between a die having a light diffracting pattern in relief thereon and a support layer of relatively stiff material.

27. A process of making a readable record comprising preparing a die having a light diffracting pattern in relief in its surface, preparing a pattern-receiving sheet material including a support layer and a layer of transparent material overlying the support layer and reflective at its surface farthest from the support layer, forming the reflective surface to conform to the relief pattern of said die, adhering the thus-conformed reflective surface of the sheet material to a substrate, and separating the support layer from the layer of transparent material.

28. A process for making a readable light diffracting record substantially as hereinbefore described.

29. A process for making a readable light diffracting record substantially as hereinbefore described with reference to and as illustrated in Figures 5 to 8 or Figures 9 and 8 of the accompanying drawings.

30. A document, e.g. a security document such as a banknote or credit card, which incorporates a readable light diffracting record as claimed in any one of claims 1 to 10, or a readable light diffracting record which has been made by a process as claimed in claim 11, claim 28 or claim 29, or a readable light diffracting pattern which has been made by a process as claimed in any one of claims 12 to 26, or a readable record which has been made by a process as claimed in claim 27.

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